Electrical Safety for R&D Laboratories

Lloyd B. Gordon

April 13, 2009



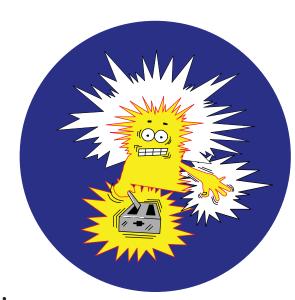
Dr. Lloyd B. Gordon

- Experimental Researcher (past)
 - Pulsed Power Engineering, Plasma Physics
- Educator
 - Professor of Electrical Engineering (past)
 - Trained over 50,000 R&D electrical workers DOE, DOD
- Electrical Safety (current)
 - LANL Chief Electrical Safety Officer
 - Annual Electrical Safety Workshop
 - Host Center of Excellence for Electrical Safety
 - Chair ISA standards committee on R&D Electrical Safety
 - National DOE Electrical Safety Committee



Since we work around *Electricity* every day, it is easy to forget how dangerous it can be.

- Over 600 people die from electrocution each year, plus 1000s in electrically caused fires
- Over 30,000 non-fatal electrical shock accidents occur each year
- Electrocution remains the fourth (4th) highest cause of industrial fatalities
- Electrical incidents are at the forefront in R&D Laboratories



Objectives

To provide a whirlwind tour of R&D Electrical Safety

 To provide you with resources to improve electrical safety in your research organization.

 To benefit from the development of these tools at large R&D Laboratories over the past 20 years.



Primary National Electrical Standards

- OSHA Code of Federal Regulations
- NEC Standard for the safe installation of electrical wiring
- NFPA 70E Standard for electrical safe work practices



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QuickTime[™] and a decompressor are needed to see this picture.



Covers 60 Hz hazards, written for facility designers and workers

R&D Workers work with

- ac, dc, rf, pulsed electrical energy
- High Voltage kV to MV
- High Current kA to MA
- High Power kW to TW
- High Energy



Lasers - one example of hazardous R&D equipment



Types of Electrical Equipment found in R&D

- 60 Hz power distribution
- dc power supplies
- capacitors
- inductors
- batteries
- pulsed systems
- rf systems (> 3000 Hz)

NOTE: NFPA 70E clearly applies to 60 Hz power distribution. The principles of 70E need to be applied to other forms of electrical energy, but 70E does not have adequate tools to determine correct controls such as PPE.



What Standards can we use for R&D Laboratories?

- The analysis and management of such unique hazards is not adequately covered by NFPA 70E, Standard for Electrical Safety in the Workplace
- How do we apply the principles NFPA 70E to R&D work?
- How do we apply the design principles in the NEC and UL standards to R&D design?



R&D Electrical Accidents

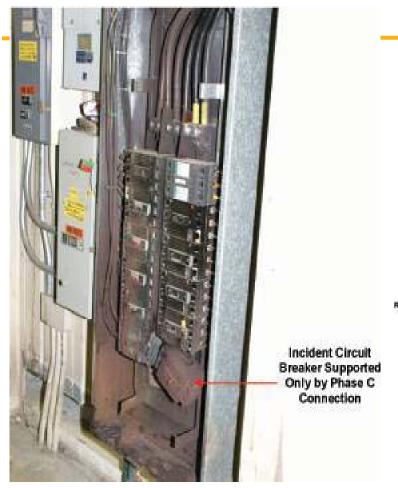
- October 11, 2004 electrician, SLAC
 - 480 V, three phase fault
 - 3rd degree burns over 50% of his body
 - Inadequate arc flash PPE
- April 14, 2006 R&D engineer, Brookhaven National Lab
 - 480 V, three phase, 400 A disconnect switch failure
 - 1st and 2nd degree burns
 - Inadequate arc flash PPE
- 1980s University graduate student fatality on high voltage system
- 1990s University graduate student seriously injured on laser
- 1996 Los Alamos student in hospital 3 days, HV capacitor
- March 2009 Army Research Lab fatality on HV capacitor



Brookhaven, April 14, 2006, R&D worker



SLAC, October 11, 2004 - electrician





Worker received 3rd degree burns



History of Electrical Safety - Design (Engineering Controls)

- 1880 first electrical codes (NEC and UL) (to prevent fire and protect buildings and equipment)
- 1960s equipment ground implemented (to prevent electrocution and protect equipment)
- 1970s Ground Fault Circuit Interrupter (GFCI) (to prevent electrocution, mostly wet environments)
- 2002 Arc Fault Circuit Interrupter (AFCI) (to prevent death by fire and smoke in bedrooms)



History of Electrical Safety - Personnel Safety

1930s - first studies on the effects of electricity

1930s - UL standards for protection of the public

1970 - OSHA and NIOSH created

1979 - NFPA 70E - focused on protection against shock

1995 - NFPA 70E - added protection against arc flash

NFPA 70E - Standard for Electrical Safety in the Workplace (2009)



History of Electrical Safety in Research Laboratories

- 1950 Charles Dalziel stated that "electrical safety in research and university laboratories is abysmal.....this work environment has special needs"
- 1980s began training programs for R&D workers
- 1990s DOE Electrical Safety Handbook
- 1990s in some University curricula
- 2000s rapid growth



Elements of an Electrical Safety Program

- Establishment of an Authority Having Jurisdiction (AHJ)
 - Roles and Responsibilities
- Electrical Hazard Classification
- Qualification and Training
 - Recognition of Hazards
 - Methods to Control Hazards
- Engineering Controls
 - Equipment Approval Program
 - Standards, external and internal
- Administrative Controls
 - Work Control
 - Two person rule
 - Work control
 - PPE
 - Qualification and Training
- Assessment

Managing the Electrical Hazard

Engineering Controls

enclosures breakers, fuses grounds, GFCIs insulation, interlocks

Administrative Controls

Safety training



Work Control

Warnings



Two person rule







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Authority Having Jurisdiction

- NEC city and state inspector
- Industry OSHA

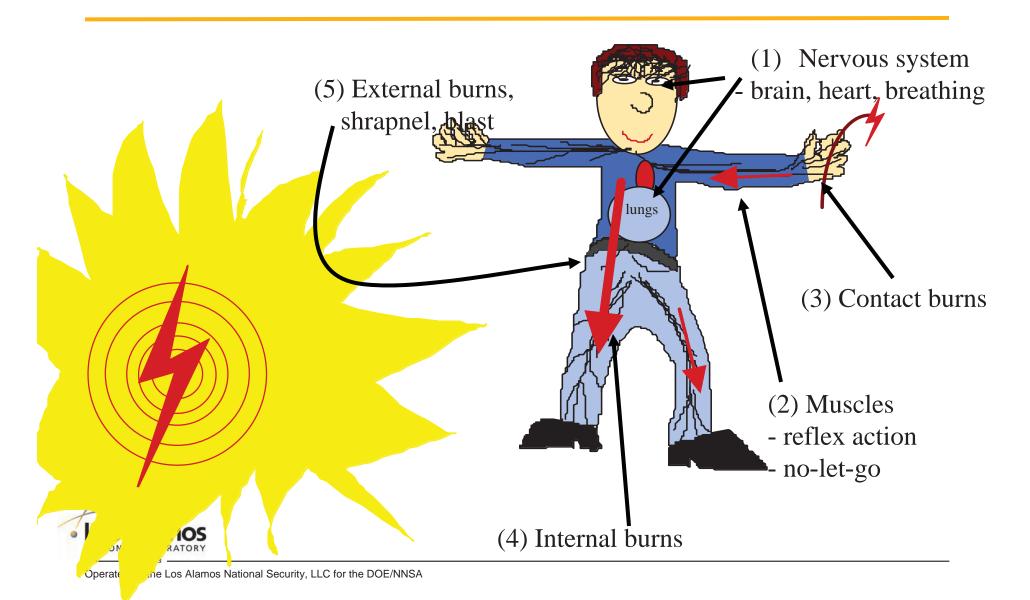
 At large R&D laboratories, and electrical safety program should be established with an AHJ (person or persons) overseeing electrical safety



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Classes of injury from electricity



Shock Electrical Waveforms

waveform - The shape of a parameter (such as voltage or current), when displayed as a function of time

alternating current (ac) - A periodic current or voltage, the average value of which over a period is zero

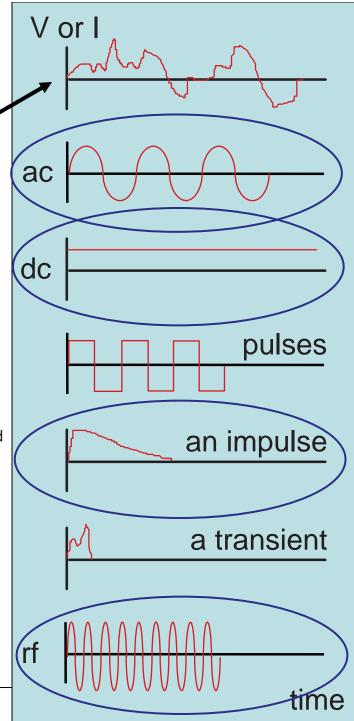
direct current (dc) - Usually a constant, non-time varying current or voltage. It may be positive or negative.

pulse - The variation of a quantity having a normally constant value. An abrupt change in voltage, or current, either positive or negative, which conveys information or transfers power to a circuit.

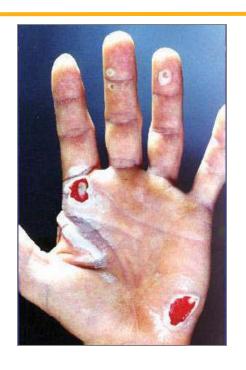
impulse - A pulse that begins and ends within a short time period. Although the time duration may be short, in high power impulses the current, voltage, and power can be very large.

transient - A momentary surge on a signal or power line. It may produce false signals or triggering impulses and cause insulation or component breakdowns and failures or may result in a prefire.

radiofrequency (rf) - A special term for high frequency (kiloHertz to gigaHertz) ac signals.



External Electrical Burns Injury





1000 W rule





HV breakdown of skin with entrance/exit wounds

What is an Arc Flash?

 According to NFPA 70E, arc flash is a "dangerous condition associated with the release of energy* caused by an electrical arc."

QuickTime™ and a decompressor are needed to see this picture.

- Arc Flash of this type, typically less than a second in duration, can reach temperatures of up to or beyond 35,000 degree F at the arc point.
- Arc flash produces intense thermal radiation, noise, explosive expansion of surrounding air due to rapid heating, and melting/vaporization of metal components in the vicinity of the arc.

facility power and > 250 V and > 500 A rule



*Energy is a function of the available fault current at the point in the electrical system.



Arc Flash Events in Electrical Equipment



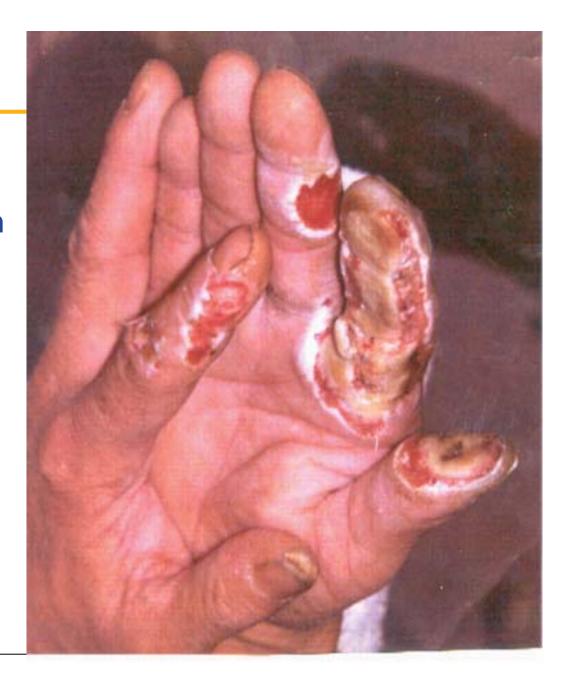
Note: Copper expands 30,000 times when vaporized!



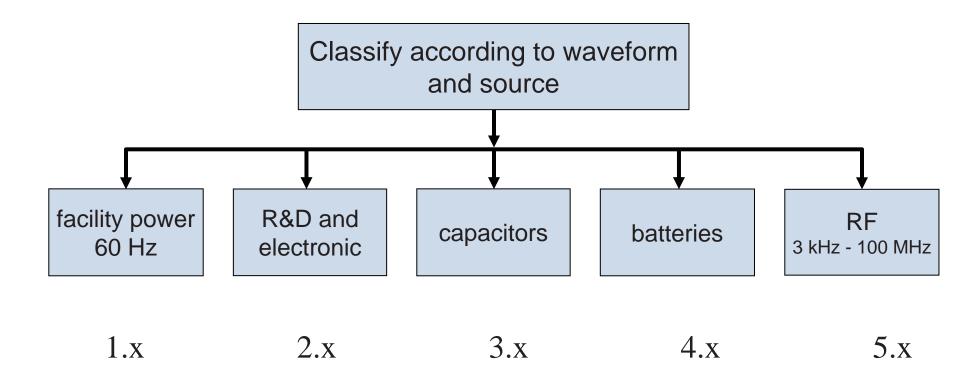
Burn injury from an arc flash in the hands

Note: no PPE was worn.





Electrical Hazard Classification





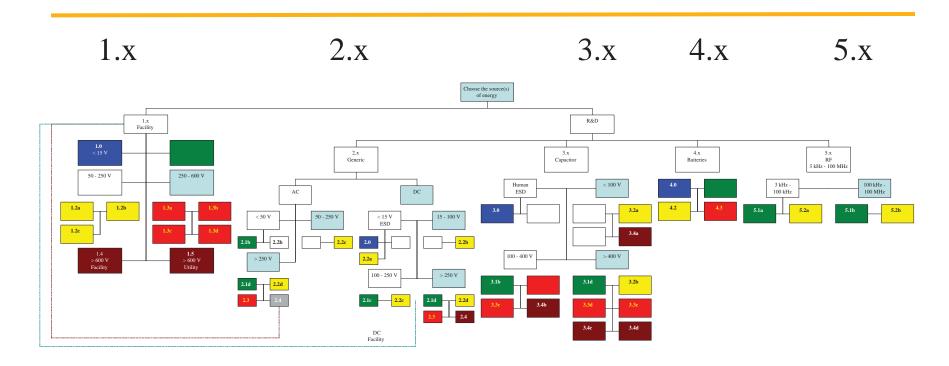
General Categories

General Features of Electrical Hazard Classification

- $\chi_{.0}$ = no hazard, no controls, no training (blue)
- X.1= minimum hazard, no injury, no controls, minimum training (green)
- X.2= can injure or kill, controls, some PPE (yellow)
- X.3= will injure or kill, controls, PPE (red)
- X.4= very serious, many controls, avoid work (maroon)



Electrical Hazard Classification Organizational Table



60 Hz

ac

dc

capacitors

batteries

RF



hazards - covers ALL electrical hazards

Hazard Analysis

- NFPA 70E deals only with some electrical hazards:
 - shock
 - thermal injury from arc flash
 - injury to neck and face due to flying objects (part of the arc blast hazard)
- NFPA 70E clearly deals most completely with 60 Hz forms of electrical energy
- NFPA 70E does NOT deal with:
 - reflex action
 - thermal burns from high current
 - arc blast (shock wave, magnetic forces, noise hazard, etc.)
- NFPA 70E does NOT provide methods to deal with:
 - dc and capacitors
 - high voltage, low current
 - low voltage, high current
 - batteries
 - radio frequency



A Complete Hazard Analysis Process for R&D

- Determine the waveform of the electrical energy
 - 60 Hz, other ac, dc, rf, pulsed
- Determine the source
 - facility power, dc power supply, capacitor, battery, rf, pulsed source
- Determine the parameters
 - voltage, current, power, energy
- Determine the need for specific analyses
 - shock boundaries
 - arc flash boundary
 - arc blast (acoustic, mechanical, electromagnetic, optical)
 - thermal burn
 - rf shock and burn
 - chemical and other secondary hazards



Selection of Controls

- Based on hazard analysis the worker chooses the correct controls, including:
 - Training and qualification
 - Can work alone, 2nd person, or safety watch
 - Needs work control (IWD and possibly EEWP)
 - Proper PPE, if needed (for shock, arc flash, noise, and/or arc blast)



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Electrical Worker Qualification

- The user/operator of electrical equipment
 - Protected by engineering controls
 - Usually not qualified to work on or near exposed electrical hazards
- The electrical worker, working on or near electrical hazards
- Qualified Worker One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on how to recognize and avoid the hazards involved.



OSHA Requirements for Qualification

- A qualified electrical worker must be trained and competent to:
 - distinguish live parts from other parts of equipment
 - determine the nominal voltage of live parts
 - know the minimum approach distances to exposed live parts
 - know what precautions to take to work safely, including:
 - how to carry out lockout/tagout procedures
 - how to manage and maintain a safe work area
 - how to use protective grounds
 - know how to choose and use PPE
 - know how to use insulating and shielding materials
 - know how to use insulated tools and test instruments



We must provide specialized training for R&D electrical hazards.

OSHA Requirements for Electrical Worker Qualification

Only qualified persons may

- work on energized electric circuits
- may perform tests on electric circuits and equipment
- may work on or with exposed lines or parts of equipment
- may work in areas containing unguarded, uninsulated energized lines or parts of equipment operating at 50 V or more

We must provide specialized training for R&D electrical hazards.



Qualified & Authorized Persons

- Trained to identify hazards
- Trained in safe work procedures to handle hazards
- Trained for the appropriate energy control method (e.g., LOTO, plug control)
- Trained to use the correct tools and personal protective equipment (PPE)
- Authorized by the appropriate responsible manager





R&D Workers and Electrical Hazards

- Users of listed or approved electrical equipment need to know of electrical hazards, but should not be exposed to them, they can be non-energized electrical workers
- R&D workers who work on or near electrical hazards must be trained as energized electrical workers
- Classes of R&D electrical work
 - low energy, plug controlled (~75%)
 - high voltage, current, power, energy (~20%)
 - exposed to facility hazards, even in some R&D equipment (~5% or greater)

Note: The class of electrical work will vary depending on field of research. A chemist or biologist will typically work with low energy, plug controlled equipment. A plasma physicist or accelerator engineer will work with high voltage, high current, high power electrical equipment.

Example Electrical Safety Training Plans

- R&D Electrical Worker: Energized
- R&D Electrical Workers: Non-energized
- Electrical Safety Officer
- Electricians/Apprentice Electricians
- Linemen & Utility Engineers
- General Workers: Electrical Hazards



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OSHA Requirement

- All electrical equipment in the workplace must be "Acceptable" for safe use. Acceptable means:
 - Must be listed by a Nationally Recognized Testing Laboratory, or
 - Inspected and approved by the local AHJ



Nationally Recognized Testing Laboratory (NRTL)

NRTLs are third-party organizations <u>Recognized</u> by OSHA as having the Capability to provide <u>Product Safety</u> <u>Testing</u> and <u>Certification</u> services to Manufacturers of a wide range of Products for use in the American Workplace. Such as Underwriters <u>Laboratories</u>.





Engineering Controls assured by NRTL listing

The following are the NRTLs recognized by OSHA for electrical equipment







































R&D Laboratories

- Have lots of unlisted, custom built electrical equipment
- Since 1998 R&D labs have started developing in-house programs to inspect and approve unlisted electrical equipment



Elements of an Electrical Safety Program

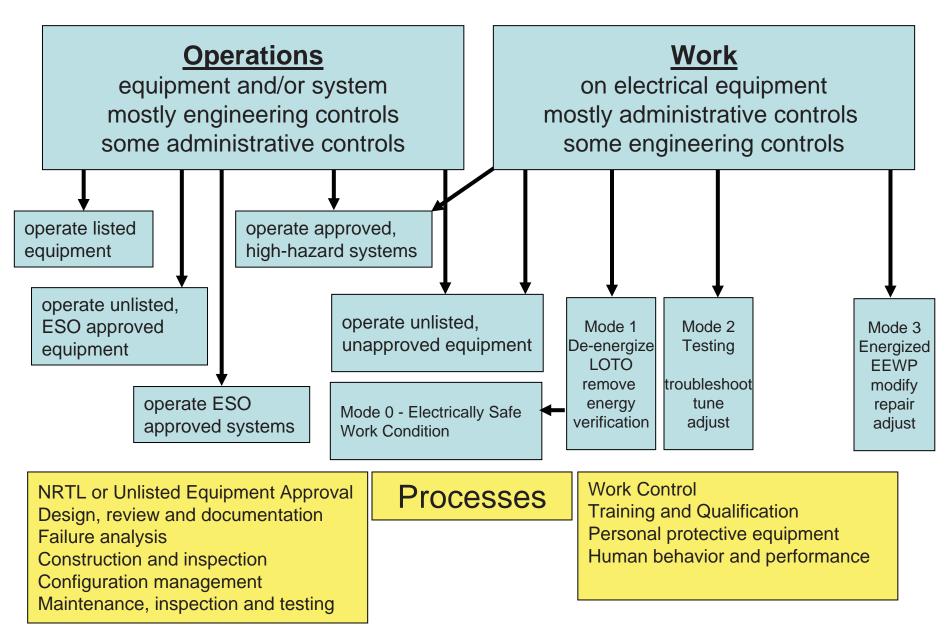
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4 Modes of Electrical Work

- Mode 0 Electrically Safe Work Condition
- Mode 1 Establishing an Electrically Safe Work Condition
- Mode 2 Energized Diagnostics and Testing
- Mode 3 Energized Work Requiring an Energized Electrical Work Permit



Worker Interface with Electrical Hazards



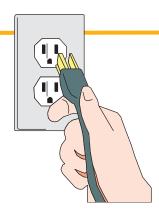
Major Categories of Worker Interface with Electrical Equipment

- Operating Equipment with engineering controls in place
 - Training nonenergized worker, or none
 - Equipment must be NRTL listed or AHJ approved
- Designing, building, and/or approving electrical equipment
 - Training to design and build electrical worker (nonenergized or energized)
 - Training to approve AHJ training and authorization
- Working on electrical equipment (hazard class X.0 or X.1, Mode 0 any class)
 - Training nonenergized or energized electrical worker
- Working on electrical equipment (hazard class X.2 and above)
 - Training energized electrical worker
 - Documented qualifications



Controlling Hazardous Electrical Energy

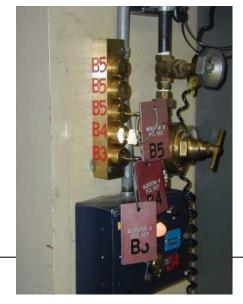
Plug Control



Lockout/Tagout Control



Engineering Control





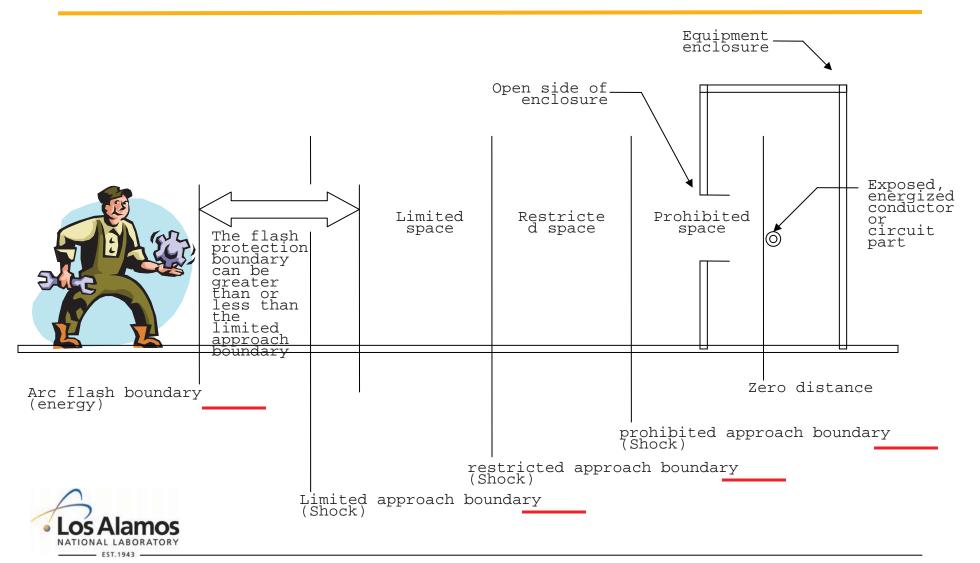
Lockout/Tagout for Personal Safety

- Purpose
- Protect workers during service, maintenance, or modification of machines, equipment, and systems
- Comply with OSHA requirements for hazardous energy control
- An individual Red lock is used to protect workers working on equipment.





Boundaries for Electric Hazards



NFPA 70E Shock Boundaries for 60 Hz

(1)	(2)	(3)	(4)	(5)
Nominal System	Limited Appro	ach Boundary	Restricted	Prohibited
Voltage Range, Phase to Phase	Exposed Movable Conductor	Exposed Fixed Circuit Part	Approach Boundary, Includes Inadvertent Movement Adder	Approach Boundary
< 50	Not specified	Not specified	Not specified	Not specified
50 – 300	3.05 m (10'0")	1.07 m (3'6")	Avoid contact	Avoid contact
301 – 750	3.05 m (10'0")	1.07 m (3'6")	304 mm (1'0")	25 mm (0'1")
751 – 15 kV	3.05 m (10'0")	1.53 m (5'0")	660 mm (2'2")	178 mm (0'7")
15.1 – 36 kV	3.05 m (10'0")	1.83 m (6'0")	787 mm (2'7")	254 mm (0'10")
36.1 – 46 kV	3.05 m (10'0")	2.44 m (8'0")	838 mm (2'9")	432 mm (1'5")
46.1 – 72.5 kV	3.05 m (10'0")	2.44 m (8'0")	965 mm (3'2")	635 mm (2'1")
72.6 – 121 kV	3.25 m (10'8")	2.44 m (8'0")	991 mm (3'3")	813 mm (2'8")
138 – 145 kV	3.36 m (11'0")	3.05 m (10'0")	1.1 m (3'7")	940 mm (3'1")
161 – 169 kV	3.56 m (11'8")	3.56 m (11'8")	1.22 m (4'0")	1.07 m (3'6")
230 – 242 kV	3.97 m (13'0")	3.97 m (13'0")	1.6 m (5'3")	1.45 m (4'9")
345 – 362 kV	4.68 m (15'4")	4.68 m (15'4")	2.59 m (8'6")	2.44 m (8'0")
500 - 550 kV	5.8 m (19'0")	5.8 m (19'0")	3.43 m (11'3")	3.28 m (10'9")
765 – 800 kV	7.24 m (23'9")	7.24 m (23'9")	4.55 m (14'11")	4.4 m (14'5")

Shock Boundaries for DC, based on NFPA 70E

(1)	(2)	(3)	(4)	(5)
Nominal Voltage Conductor to Ground	Limited Appro	ach Boundary	Restricted	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part	Approach Boundary, Includes Inadvertent Movement Adder	
< 100	Not specified	Not specified	Not specified	Not specified
100 – 300	3.05 m (10'0")	1.07 m (3'6")	Avoid contact	Avoid contact
301 – 750	3.05 m (10'0")	1.07 m (3'6")	304 mm (1'0")	25 mm (0'1")
751 – 15 kV	3.05 m (10'0")	1.53 m (5'0")	660 mm (2'2")	178 mm (0'7")
15 kV – 45 kV	3.05 m (10'0")	2.5 m (8'0")	0.8 m (2'9")	0.44 m (1'5")
45 kV – 75 kV	3.05 m (10'0")	2.5 m (8'0")	1 m (3'2")	0.65 m (2'1")
75 kV – 150 kV	3.4 m (10'8")	3 m (10'0")	1.2 mm (4'0")	1 mm (3'2"")
150 kV – 250 kV	4 m (11'8")	4 m (11'8")	1.6 m (5'3")	1.5 m (5'0")
250 kV – 500 kV	6 m (20'0")	6 m (20'0")	3.5 m (11'6")	3.3 m (10'10")
500 kV – 800 kV	8 m (26'0")	8 m (26'0")	5 m (16'5")	5 m (16'5")



With leather protectors

Dielectric Gloves

Class 00 500 V

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Class 0

1000 V

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Class 1

7500 V

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• Class 2

17,000 \

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• Class 3

26,500 V

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Class 4

36,000 V

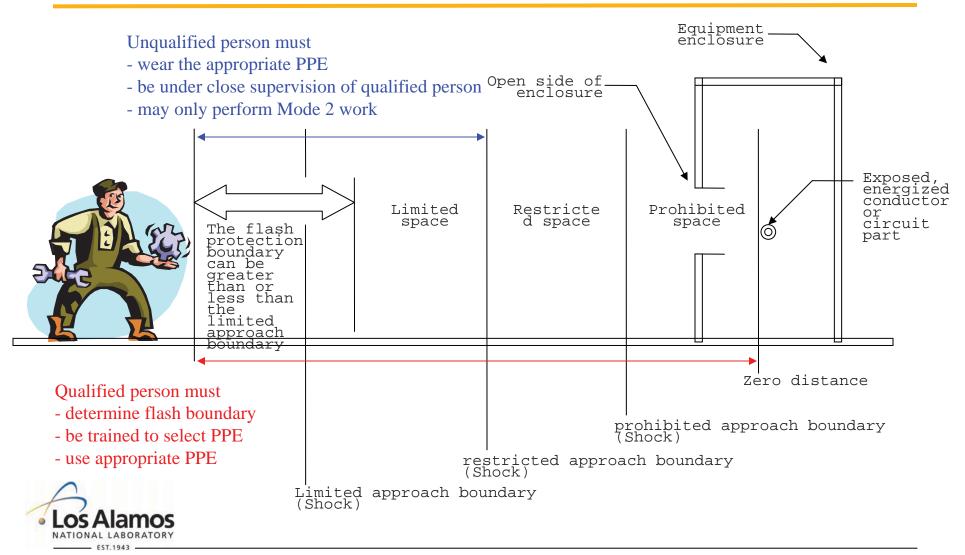
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Summary of Rules for Arc Flash Boundary



Example Energies in facility system arcs

Bus voltage	Short Circuit Current	Power (peak)	Clearing Time of Fault	Energy in Arc	Typical Arc Flash Boundary
120 V	3,000 A	360 kW	0.1 s	36 kJ	
240 V	10,000 A	2.4 MW	0.1 s	0.2 MJ	
480 V	15,000 A	7.2 MW	0.1 s	0.7 MJ	1 m
4160 V	25,000 A	104 MW	0.1 s	10 MJ	2.2 m
13.8 kV	31,000 A	430 MW	0.1 s	42 MJ	4 m

Note 1: Clearing time can be reduced by fast acting fuses

Note 2: Clearing time can be longer, if overcurrent protection fails to operate, or if it operates slowly for coordination purposes.

Furnace controller showing input hazards



Input - 480 V, 3φ, 25 A adjacent to control circuits

All hazards must be analyzed and proper PPE must be used.



Operated by the Los Alamos National Security, LLC for the D

Examples of Energies and Arc Flash Boundaries for various capacitors The arc flash boundary for the action to select the calculated.

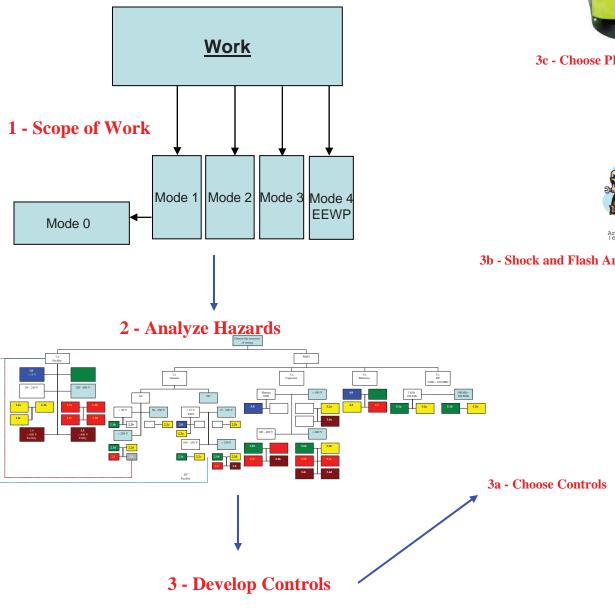
The arc flash boundary for the ac input power must be calculated

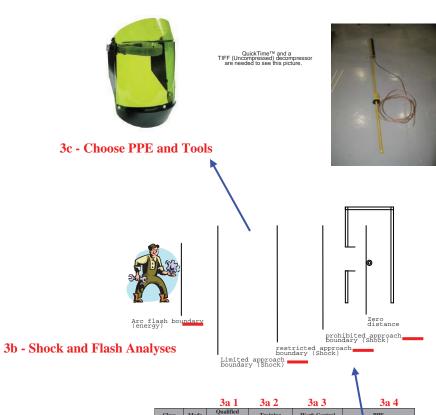
Туре	Voltage	Energy	Arc Flash Boundary
Cathode Ray Tube	40,000 V	0.1 J	0.1 mm
High Pot Tester	60,000 V	0.1 J	0.1 mm
Microwave Oven	4,000 V	10 J	0.7 cm
High Power Laser	10,000 V	1000 J	7 cm
X-ray Source	100,000 V	10 J	0.7 cm
Energy storage Cap	60,000 V	200 kJ	1 m
Capacitor Bank	60,000 V	1 MJ	2 m



Note: most of these are well within the Prohibited Approach Boundary

Process to Develop Work Controls





		3a 1	3a 2	3a 3		3a 4
Class	Mode	Qualified Worker(s)	Training	Work Control	\	PPE
	ALL	Alone	None	None	None	
	ALL	Alone	Non-Energized	None	None	
2.2a	0	Alone	Non-Energized and LOTO	None	None	1
	1	Alone	Energized	IWD	Shock I	lazard Analysis
	2	Two person	Energized	IWD	Shock I	Hazard Analysis
	3	Two person	Energized	IWD	Shock I	lazard Analysis
	2	Safety Watch	Energized	IWD, EEWP	Shock I	lazard Analysis
2.2b	0	Alone	Non-Energized and LOTO	None	None	
	1	Alone	Energized	IWD	Shock I	lazard Analysis
4	2	Two person	Energized	IWD		lazard Analysis
	3	Two person	Energized	IWD	Shock I	lazard Analysis
	2	Safety Watch	Energized	IWD, EEWP	Shock I	Iazard Analysis
2.2c	0	Alone	Non-Energized and LOTO	None	None	,
	1	Alone	Energized	IWD	Shock I	lazard Analysis
4	2	Two person	Energized	IWD	Shock I	lazard Analysis
	3	Two person	Energized	IWD	Shock I	Hazard Analysis
	2	Safety Watch	Energized	IWD, EEWP	Shock I	Hazard Analysis
2.2d	0	Alone	Non-Energized and LOTO	None	None	
	1	Alone	Energized	IWD	Shock I	Hazard Analysis
4	2	Two person	Energized	IWD	Shock I	lazard Analysis
	3	Two person	Energized	IWD	Shock I	lazard Analysis
	2	Safety Watch	Energized	IWD, EEWP	Shock I	lazard Analysis
2.3	0	Alone	Non-Energized and LOTO	None	None	
	1	Two person	Energized	IWD	Shock I	lazard Analysis
4	3	Safety Watch	Energized	IWD	Shock I	lazard Analysis
	3	Safety Watch	Energized	IWD	Shock I	Hazard Analysis
	2	Safety Watch	Energized	IWD, EEWP	Shock I	Hazard Analysis
2.4 ¹	0	Alone	Non-Energized and LOTO	None	None	
4	1	Safety Watch	Energized	IWD		Iazard Analysis and azard Analysis
	2	Safety Watch	Energized	IWD	Shock I	Hazard Analysis and azard Analysis
	3	Safety Watch	Energized	IWD	Shock I	Jazard Analysis and azard Analysis
2	2	Safety Watch	Energized	IWD, EEWP	Shock I	Hazard Analysis and azard Analysis

4

Summary - key Issues for R&D

- The principles of NFPA 70E should be applied to all hazardous electrical equipment
- NFPA 70E does NOT provide the tools for determination of arc flash boundaries for DC, capacitors, RF, batteries, etc.
- R&D workers must understand shock and arc flash hazards
- R&D workers must be able to determine shock and arc flash boundaries for their work

High Voltage Safety



Face and Hearing PPE for Safing Capacitors

For high voltage capacitors (> 400 V) use PPE

energy	<u>PPE</u>	safety ground
0 - 0.25 J	none	hard ground, if desired
0.25 - 1 J	none	hard ground hook
1 - 10 J	eye	hard ground hook
10 - 1000 J	eye, ear	hard or soft ground hook
1 - 10 kJ	face, ear	soft ground hook
> 10 kJ	optional	remotely



Personal Safety Grounds

- For use on charged capacitors ground hooks must be designed for the voltage, tested periodically, and visually inspected before each use.
- PPE for using ground hooks should use a graded approach.
- Ground hooks should never be used on charged capacitors above a certain energy due to arc blast hazards, engineering controls must be used to remove energy before approach.
- Ground hooks on high energy capacitors are a visual indicator to unqualified workers that the system is in an electrical safe condition.

A ground hook training, testing, care, inspection process is under development.

Capacitors

The stored energy can be hazardous and lethal.

Electrical Energy = Joules (J)





Greater than 10J is hazardous

Greater than 50J is potentially lethal

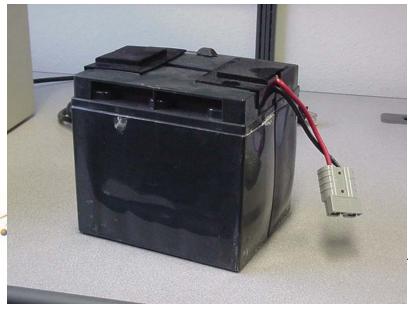
Battery Safety

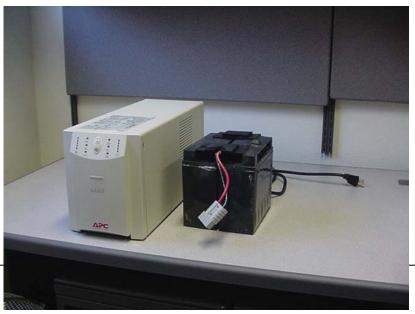


These failed UPS batteries are from LANL!









Batteries and Battery Banks

Exposed terminals of a battery present a burn hazard, e.g., car battery.



Exposed terminals of battery banks present a shock and burn hazard.





Operated by the Los Alamos National Security, LLC for the DOE/NNSA

Lilon battery explosion in R&D equipment



Equipment Inspection



Inspect Cords Before Each Use

Remove From Service Damaged or Frayed Cords









Stay clear of bare exposed wiring!

Computer Safety

- A Electrical Shock Hazards
- B. Electrostatic Discharge (ESD)
- C. Uninterruptible Power Supplies (UPS)



Non-ionizing Radiation Safety

- Static Electric and Magnetic Fields
- Sub-Radiofrequency Electric and Magnetic Fields (1 Hz 3 kHz)
- Radiofrequency and Microwave Radiation (3 kHz 300 GHz)



Proper Use of Electrical Equipment



Never daisy chain multioutlet strips (plugging into each other)





Sometimes users misuse electrical equipment

A motor was plugged into a power strip.



Use electrical equipment as it was intended per the manufacturer's instructions.



Recalls







Lightning and Outdoor Safety





Lightning Facts

- More deaths occur per year from lightning than tornadoes and hurricanes combined.
- Avoid high places, open fields, water, trees, and other tall and/or metal structures.
- If you hear thunder over head, you may be struck by lightning.
- If outside, seek shelter immediately!





Power Lines can Kill!

Stay away from

Overhead



Downed



Underground





Electrostatic Discharge Safety







Resources for YOUR use

- Center of Excellence for Electrical Safety website, http://www.lanl.gov/safety/electrical/
 - many resources for the R&D community
- To find this website, Google: Center of Excellence Electrical Safety



Government and National Codes and Standards for Electrical Safety

- OSHA Title 29, parts CFR 1910 and 1926
- NEC National Electrical Code 2008
- NFPA 70E Standard for Electrical Safety in the Workplace (2009)
- DOE Electrical Safety Handbook (2004)
- ASTM, ANSI, and IEEE Standards
- NRTL Standards (e.g., UL)
- NESC National Electrical Safety Code, IEEE C2



Electrical Training for R&D Workers in DOE

- Electrical Safety for R&D Workers
- Electrical Work Hazard Analysis for R&D Workers based on the Principles of NFPA 70E
- R&D Focus Classes (2 hours each)
 - Pulsed Power Safety
 - Radiofrequency and Microwave Safety
 - Computer Safety
 - Batteries and Battery Bank Safety
 - Basic Facility Wiring Principles
 - Basics of R&D Grounding and Shielding
 - Introduction to Electrical Theory
 - Designing Safe Electrical Equipment
- Electrical Safety for Subject Matter Experts (3 to 5 days)



Center of Excellence for Electrical Safety

About the Center of Excellence for Electrical Safety

The purpose of this website is to provide members of the Electrical Safety Community resources on electrical safety, including standards, references, best practices, events, issues, training materials, lessons learned, and more. By creating a centralized location for electrical safety resources we hope to promote communication, collaboration, and improvement in electrical safety. Our goal is to provide centralized resources on electrical safety for the DOE complex.





DOE Electrical Safety Handbook Electrical Safety Meetings and







About Us

Resources

Training

Media

Setting the Standard for Electrical Safety



Learning from our past



Procedures and Planning



R&D Process Development

CONTACTS

Electrical Safety

Home

FOCUS AREAS

Workshops

R&D Electrical Safety

Subcontractor and Facility

Ask the Expert

Electrical Safety Task Group

Electrical Safety Task Group Subcommittees

Site AHJ Contacts

Center of Excellence Contacts Lloyd Gordon (505) 667-0778 Anthony Cuaron (505) 667-4102

search this site

Search

NEWS, ALERTS, ANNOUNCEMENTS

- "The Wrong Way" photos posted
- TEKTRONIX PRODUCT SAFETY NOTICE
- OSHA Revises its Electrical Installation Standard found in Subpart S of 29 CFR Part 1910
- New ASTM International Protective Equipment Standard to Measure Electric Arc Exposure
- Recall: Clothing Irons Recalled by Conair Corporation Due to Fire Hazard (Tue, 31 Mar 2009 18:30:00 GMT) The clothing iron can overheat, posing a fire hazard to consumers.
- >> See more recalls . . .

Electrical Safety Video



Before Lightning Strikes (mpg)

Suggestions for content?

Please email us with ideas, input or requests.

LESSONS LEARNED

- Safety Flash: Lithium Battery Safety
- Arc Flash Video, Pacific Northwest National Laboratory (wmv)
- Electrical Plug Incident, Argonne National Laboratory (ppt)
- Inadequate Planning Causes Power Outage, Fluor Hanford (pdf)
- Foreign Made Lithium Battery Causes Fire, Fluor Hanford (pdf)
- Recent Electrical Events
 Highlight Equipment-Failure
 Hazards, LANL (pdf)
- Subcontractor electrician triggers 480V arc flash, LANL (pdf)
- 2 workers endangered in nearmiss, LANL (pdf)
- Worker Receives Electrical Shock After Contact with Welder Cart, LANL (pdf)

DOE LESSONS LEARNED

BEST PRACTICES

The Center of Excellence Best Practices process is intended to communicate initiatives that are innovative, represent actions beyond generally accepted standards or application of standards to new functional area, or that significantly increase the efficiency or effectiveness of electrical safety operations at DOE/NNSA Facilities.

- View the Center of Excellence Best Practices
- Guidance for Submission of Best Practices
- Template for developing your
 Best Practice submittal
 document

RELATED LINKS

Government

Office and Family

Electrical Safety at Various Sites

Electrical Safety Information Standards

Nationally Recognized Testing Laboratories (NRTLs)



Related Links

Government

- Department of Energy (DOE)
- DOE Electrical Safety
- Defense Nuclear Facilities Safety Board (DNFSB)
- □ Energy Facility Contractors Group (EFCOG)
- EFCOG Electrical Safety
- National Nuclear Security Administration (NNSA)
- Occupational Safety & Health Administration (OSHA)
- Western Area Power Administration
- Army Safety Program (pdf)

Office and Family

- Consumer Product Safety Commission (CPSC)
- Electrical Safety Foundation International (ESFI)
- Frankenstein's Lightning Laboratory Electrical Safety

Electrical Safety at Various Sites

- Brookhaven National Laboratory Electrical Safety Progra
- Electrical Safety at CERN
- LLNL Electrical Safety Program, ES&H Manual (pdf)
- SLAC Electrical Safety Support Group

Electrical Safety Information

- ArcWear
- Arc Flash & Electrical Safety News
- DOE Electrical Safety Campaign
- DOE R&D Electrical Safety
- DOE Technical Standards
- Electrical Safety Foundation International website
- Electric Substation Safety Resource Site
- IEEE Standards Association Electrical Safety Resource Center
- Saskatchewan Electrical League

Standards

- Institute of Electrical and Electronics Engineers, Inc (IEEE)
- American National Standards Institute (ANSI)
- National Fire Protection Association (NFPA)
- American Society for Testing and Materials (ASTM)
- National Electrical Manufacturers Association (NEMA)
- European Committee for Electrotechnical Standardization (CENELEC)
- International Electrotechnical Commission (IEC)

Nationally Recognized Testing Laboratories (NRTLs)

- Underwriter's Laboratory- United State and Canada
- TUV Rheinland- United States, Canada and Europe
- CSA- International- United States and Canada
- TUV America- United States and Canada

Electrical Training & Qualification Resources

Facility Electrical Worker Training

- Electrical Measurement Safety 09/17/07
- Test Before Touching (pdf) 01/26/07
- Potential Hazards with Neutral Conductors (ppt) 01/03/07

Collapse

Facility Non-Electrical Worker Training

- Module 1 General Electrical Safety Awareness (ppt) 12/05/06
- Module 2 Electrical Cord Safety (ppt) 12/05/06
- Module 3 Electrical Safety for Arc Welding and Plasma Cutting (ppt) 12/05/06
- Module 4 Electrical Safety Working Near Overhead Power Lines (ppt) 12/05/06
- Module 5 Electrical Safety During Excavation and Trenching (ppt) 12/05/06
- Module 6 Electrical Safety for Skilled Worker (ppt) 12/05/06
- Module 7 Electrical Safety for Radiological Control Technician (ppt) 09/17/07
- Module 8 Electrical Safety for Subcontractors 09/17/07
- Module 9 Battery Safety and Handling 09/17/07
- Electrical Safety Awareness Study Guide for Instructors and Students (pdf)- 12/05/06



Supplementary Training Resources

- Arc-Flash Safety Handbook (Littlefuse) (pdf) 09/17/07
- NIOSH Electrical Safety Student Manual (pdf)
- Managing Power Line Hazards (pdf) 12/05/06
- Video Boom Truck Contact with Overhead Power Line (wmv) 12/05/06
- Video An Interview With Worker After Arc-Flash Event (NIOSH) (wmv)- 09/17/07
- Video Counterfeit Electrical Cords (wmv) 09/17/07
- Video Extension Cord Safety (wmv) 09/17/07
- Video Power Line Safety (wmv) 09/17/07
- Video Wired for Safety (wmv) 09/17/07

- Collapse

R&D Worker Training

coming soon

- R&D Core Module Basic Electrical Safety For R&D Electrical Worker
- Module R&D 1 High Power Electrical Safety (HV, HC, Capacitor and Inductor safety)
- Module R&D 2 Radiofrequency and Microwave Safety
- Module R&D 3 Batteries and Battery Bank Safety
- Module R&D 4 R&D Grounding and Shielding
- Module R&D 5 Computer Safety
- Module R&D 6 Designing Safe R&D Equipment
- Module R&D 7 Basic Electrical Theory for R&D Workers
- Module R&D 8 Basic Facility Wiring Principles
- Module R&D 9 Control of Hazardous Energy in R&D Laboratory
- Module R&D 10 PPE for R&D Workers Based on NFPA 70E



Resources Equipment Approval New Products Recalls Counterfeit Products Electrical Safety Definitions (pdf) Electrical Safety Links Units & Acronyms (pdf)



MAY - National Electrical Safety Month

See
Center of Excellence for Electrical Safety
for
LOTS of helpful tools



For More Information

Contact the author

 Contact information on the Center of Excellence for Electrical Safety

